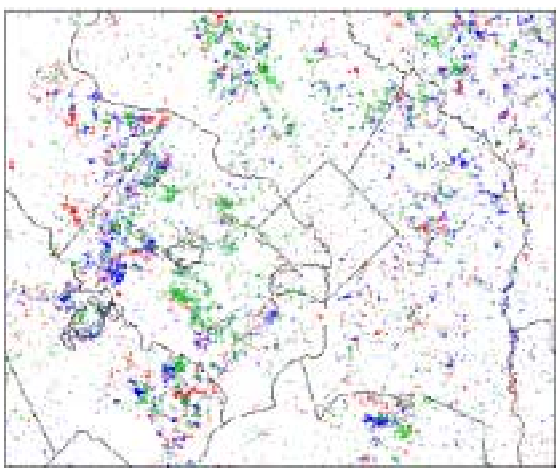
How Can We Grow Smarter?

Investigating Urban Sprawl and Land Cover Change in the Classroom

PREFACE

Beginning in 1998 the educational outreach group for NASA's Landsat 7, at the request of Project Scientist Darrel Williams, began to develop an educational unit for the Landsat Project Office (LPO.) The educational outreach group created and field-tested middle school and high school educational modules, which effectively have students use Landsat data in a variety of classroom projects. The resulting product is an interdisciplinary project designed to give teachers and their students the opportunity to develop and explore the uses of 30 years of Landsat satellite data. It was quite a task to find a broad-based application of Landsat data that students could study with some ease and would spark their interests. One of the NASA funded projects served as a perfect model. Investigators from the University of Maryland College Park Geography Department utilized historical and current Landsat data to map the patterns of urban growth and sprawl in the metropolitan area surrounding Washington D.C. (for additional information see: Growth Patterns of Urban Sprawl: How do zoning policies and environmental pressures influence the expansion of urban populations?).



Urban growth in the Washington D.C. Metropolitan area

The University of Maryland investigators worked on the premise that vegetative decrease in an area could be used to identify the location, timing and extent of urbanization. Through meetings with two of the investigators, Jeff Masek and Frank Lindsey, it became clear that students could, with some training in basic remote sensing techniques, use satellite images to help them understand their local area and how it had changed over the years. This unit is designed to be presented on the web. It was also developed to support existing curricula while promoting student inquiry. The seventh grade teachers at the Queen Anne School of Upper Marlboro Maryland worked together to create and implement this interdisciplinary project in the spring of 1999. The resources that were collected and the lessons that were developed through that collaboration have been incorporated into this web-based unit.

On this web site, teachers and students can find supporting background information, lessons for an interdisciplinary project, the required data sets, and various appendices that expand this project. Each of the links on this web site is designed for to make implementation easy for both teachers and students.

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Investigating Urban Sprawl and Land Cover Change in the Classroom

TEACHER INTRODUCTION

This interdisciplinary unit uses cross-curricular problem-solving techniques and remote sensing data to solve a proposed problem (urban sprawl) for our area. It is possible for the lessons to be implemented in only the science classroom or in a cross-curricular manner. This project asks the question: how will the local development (both industrial and residential) affect life in a community for both people and the local ecosystem. Once the students understand their local problem through the analysis of remote sensing data and additional research, they will be asked to suggest community solutions. The Maryland Smart Growth initiatives offer a model for some methods to solve urban "sprawl" growth problems.

The thematic construction of this unit has students assume the persona of various community members, developers, scientists and citizens, who have been assembled as a committee to create a request for Smart Growth funds for their area. The students, acting in their characters, have to interpret the satellite images from that character¹s perspective. The culminating event is a town meeting where the students present their findings to the community and establish the request for Smart Growth funds.

There are many ways that Landsat data is used in the social, earth, and biological sciences, from estimating soil moisture levels to documenting urban growth and observing vegetative land cover change. In this project students will utilize Landsat data to investigate vegetative land cover change in their local communities. Vegetative land cover change over time is result of natural and human induced phenomenon that encompasses a wide range of issues.

This web site provides an example of how Landsat data can be used in conjunction with local maps and aerial photographs to address questions concerning land use changes over time. Teachers are encouraged to modify the unit to focus on a problem or question relevant to their local community. There are numerous applications of Landsat data that explore geographically diverse issues. Choosing which local issue is relevant to your area is easier when you review the Applications of Landsat Data web site. A locally relevant issue will allow students to take ownership of their learning and get them involved in a way that web-based lessons cannot. To help in the modification of lessons they can be downloaded as Rich Text Format (RTF) and imported into a word processing software package to be edited.

This project is an extension of the GLOBE Program's Land Cover/Biology protocols. It makes use of the 15 km x 15-km Landsat image provided to GLOBE school participants by the GLOBE program. Additionally students will research and collect extensively from both national and local data sources as they investigate land use changes over time.

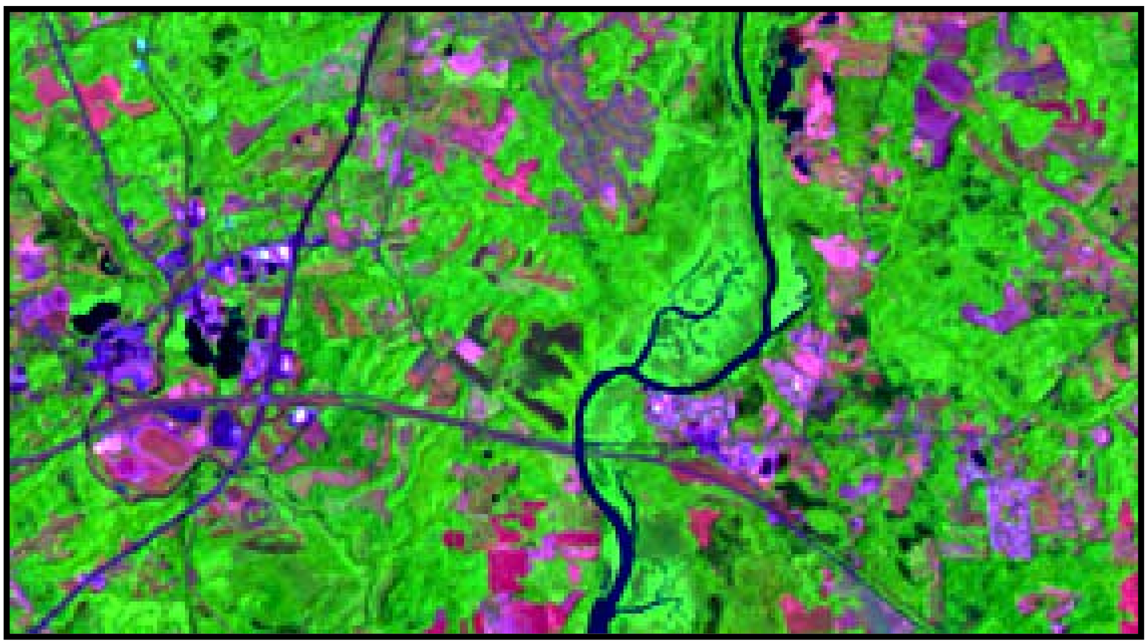

figure Intro 1. A False color image (color composite using bands 5,4,2) of Upper Marlboro, Maryland shows the differences between various vegetative types. Grasses and marshes are light green, broad leaf forests are green, and dark green displays evergreen dominated land cover. Man made land cover is shown as purple or blue, while dark blue represents open water.

Resources

Using resources listed below, the students can then develop their own maps and visually determine how their surroundings have changed and in what manner. The project is designed to allow teachers to customize the objectives to accommodate different available time commitments. It can range from a 1-2 week unit all the way to a yearlong intermittent project.

National Sources:

- National Archives and Records aerial photography records
- USDA Farm Services Agency aerial photography program
- USGS map services (for topographic maps)
- EROS Data Center NAPP Aerial Photographs

Local sources:

- County Zoning Informational Boards (for maps, aerial photographs and GIS generated maps)
- Historical Societies
- State Department of Natural Resources

  County Department of Natural Resources

Using these resources, the students can then develop their own maps and visually determine how their surroundings have changed and in what manner. The project is designed to allow teachers to customize the objectives to accommodate different available time commitments. It can range from a 1-2 week unit all the way to a yearlong intermittent project.

GENERAL UNIT OVERVIEW:
TEACHER BACKGROUND INFORMATION

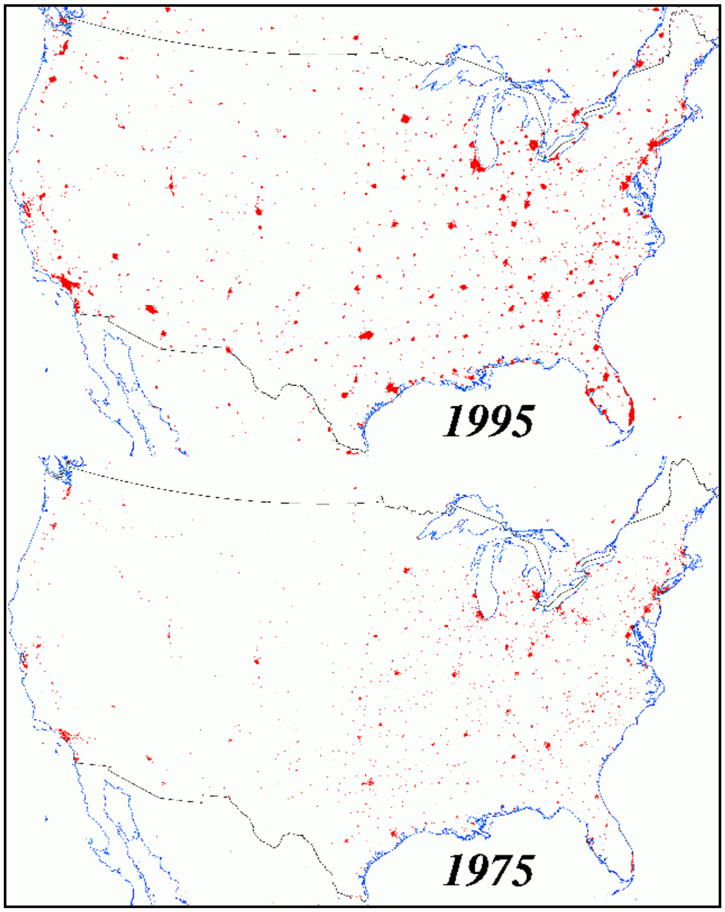

figure Intro 2. Red represents the extent of urban or built-up areas for 1975 and 1995. The 1995 data is derived from a dataset of city lights assembled by NOAA using 231 nighttime orbits of the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (Elvidge et al.,in press). The 1975 data is from Digital Chart of the World, a dataset derived by the Defense Mapping Agency from the Operational Navigation Chart (ONC) map series. http://edcwww2.cr.usgs.gov/umap/htmls/uareas.html

The Earth is constantly changing. Change over time is basic to all natural systems. The Earth has undergone changes since its formation some 4.6 billion years ago. The patterns of change vary in form, size, duration and extent. (Hidore, 1996) In his book, Global Environmental Change: Its Nature and Impact, John Hidore categorizes patterns of change into six groups: persistent, rhythmic, cyclical, short-lived, anthropogenic, and biological responses to environmental change. Anthropogenic change or human activity is increasingly considered a factor currently changing the Earth. Some anthropogenic changes may have serious impacts such as global increases in carbon dioxide levels, habitat loss and stratospheric ozone depletion. These types of changes are a concern to us all. Just in the United States alone the extent of urbanization has increased substantially in recent years. Figure 2 shows the increase in urbanization between 1975-1995. (See either USGS web site for additional information: Land Use History of North America or Urban Dynamics Research Program) For most of us it is easy to think globally; however we often have trouble understanding the part we play locally in global change.

"Human activity on Earth has reached such an intensity and such a large spatial extent that it is a major agent for a changing planet…Within the past 20,000 years, and perhaps as far back as 100,000 years, the human species has grown sufficiently in numbers and technology to produce global change." (Hidore, 1996)

To better understand the patterns of change, scientists rely on ground-based observations, observations from airborne instruments (flown on airplanes or balloons) and satellite observations.

By assessing data collected at different scales, researchers can begin to answer questions about global environmental change. This unit gives teachers the opportunity and resources to facilitate an interdisciplinary unit using remote sensing techniques and data to investigate urban sprawl and its consequences in the Washington, D.C. region. The remarks by Governor Parris N. Glendening of Maryland at the "PARTNERS FOR SMART GROWTH" conference on December 3, 1997 capture some of the complexities of this problem and some of the possible solutions as modern society faces urban sprawl and the rapid loss of forests and farms. He also offers possible solutions to this issue that has gained national and international recognition. For complete reference see Appendix E.

"How Can We Grow Smarter?" provides all the necessary materials required to address the issue of land use change and urban sprawl in the D.C. area. The unit design can be customized to suit other problems besides urban growth using the same techniques. If a school wanted to collect the same type data that we have and apply these remote sensing and other research techniques to their local area they could easily do so using the data collection Appendix C. There are numerous applications of Landsat data including:

- Precision farming land management
- Cartographic mapping and map updating
- Mapping volcanic surface deposits
- Measuring changes and extent of glacial features
- Mapping floods and flood plain characteristics
- Determining patterns and extent of turbidity
- Monitoring deforestation
- Assessing and monitoring grass and forest fires

(All the above links come from the Landsat Project's web site. For an more extensive list of possible uses of Landsat data see the Applications of Landsat Data web page. The web page has a table that lists examples of various applications of Landsat data that have been demonstrated in the 28-year history of the Landsat program. http://landsat.gsfc.nasa.gov/images/Landsat_Applications.html)

How to implement the project

This unit gives teachers the opportunity and resources to facilitate an interdisciplinary unit using remote sensing techniques and data to investigate urban sprawl and its consequences in the Washington, D.C. region. "How Can We Grow Smarter?" provides all the necessary materials required to address the issue of land use change and urban sprawl in the D.C. area. The unit design can be customized to suit other problems besides urban growth using the same techniques. If a school wanted to collect the same type data as on this web site and apply these remote sensing and other research techniques to their local area they could easily do so using the data collection Appendix C. It is possible for the lessons to be implemented in only the science classroom or in a interdisciplinary manner.

Science class implementation alone	**Interdisciplinary implementation**
This project asks the question: how will the local development (both industrial and residential) affect life in a community for both people and the local ecosystem. Once the students understand the local problem through the analysis of remote sensing data and additional research they are asked to present the environmental impact of the growth supported with remotely sensed data using Landsat data.	This interdisciplinary unit uses cross-curricular problem-solving techniques and remote sensing data to solve a proposed problem (urban sprawl) for our area. This project asks the question: how will the local development (both industrial and residential) affect life in a community for both people and the local ecosystem. Once the students understand their local problem through the analysis of remote sensing data and additional research, they will be asked to suggest community solutions. The Maryland Smart Growth initiatives offer a model for some methods to solve urban "sprawl" growth problems. In the unit the students assume the persona of various community members, developers, scientists and citizens, who have been assembled as a committee to create a request for Smart Growth funds for their area. The students, acting in their characters, have to interpret the satellite images from that character[1]s perspective. The culminating event is a town meeting where the students present their findings to the community and establish the request for Smart Growth funds.
STEP ONE: Teacher Overview 1. Collect local data for the project from either web pages or local sources. ***Science: Appendix C Data Collection*** 2. Write and mail community and parent introductory letters. 3. MultiSpec and Landsat image tutorial 4. Remote sensing tutorial 5. Optional reading "Growth Patterns of Urban Sprawl" by Masek ***Science: See Appendix F*** ***Science:*** Study population growth statistics. ***See Appendix B***	**STEP ONE:** Teacher Overview 1. Collect local data for the project from either web pages or local sources. ***Science or History: Appendix C Data Collection*** 1. Write and mail community and parent introductory letters. ***English: Optional Extension Lessons: Conducting interviews and making presentations*** 2. Provide list of community member roles to students 3. Assign roles or let students choose student research role 4. Have the students begin to create a point of view. 5. Have students, in English class; write a journal entry answering these questions about their roles life. ▪ What does your character do for a living? ▪ How did they become interested in this career? ▪ How long have they lived in the community?

	▪ What is their view of how the community changed during the time they have lived here? 6. MultiSpec and Landsat image tutorial 7. Remote sensing tutorial 8. Optional reading “Growth Patterns of Urban Sprawl” by Masek ***See Appendix F*** ***Science, History or Math:*** Study population growth statistics. ***See Appendix B***
STEP TWO: Determine extent of urban growth using Landsat and other data ***Science Activity: Studying Vegetation From Space*** ▪ Create a set of NDVI images ***Science Activity: Studying Vegetation Change From Space- Δ NDVI Calculation,*** ▪ Create a Δ NDVI image ***Science Lesson: Aerial Photograph Interpretation*** ▪ Create a selective interpretation key for and practice reading aerial photographs ***Science Lesson: Vegetative Change Detection*** ▪ Come up with hypotheses as to what changes are occurring in the local area. ▪ Look at change over time by using the ΔNDVI images with aerial photographs and other research materials. ***Science Optional Extension Lessons: Math Scaling*** ▪ Rescale maps and aerial photographs to assist in using the ΔNDVI image to detect change in the local area. ***Science Optional Extension Lessons: Interpreting Data*** ▪ Determine if urban growth could affect: environment- air quality, animals migrating, loss of habitats, increased erosion/ loss of ability of land to filter water, and loss of biodiversity. ***See Appendix A for further details***	**STEP TWO:** Determine extent of urban growth using Landsat and other data ***Science Activity: Studying Vegetation From Space*** ▪ Create a set of NDVI images ***Science Activity: Studying Vegetation Change From Space- Δ NDVI Calculation,*** ▪ Create a Δ NDVI image ***Science Lesson: Aerial Photograph Interpretation*** ▪ Create a selective interpretation key for and practice reading aerial photographs ***Science Lesson: Vegetative Change Detection*** ▪ Come up with hypotheses as to what changes are occurring in the local area. ▪ Look at change over time by using the ΔNDVI images with aerial photographs and other research materials. ***Math Optional Extension Lessons: Math Scaling*** ▪ Rescale maps and aerial photographs to assist in using the ΔNDVI image to detect change in the local area. ***Math and or History Optional Extension Lessons: Interpreting Data*** ▪ Determine if urban growth could affect: environment- air quality, animals migrating, loss of habitats, increased erosion/ loss of ability of land to filter water, and loss of biodiversity. ▪ Appearance of town. ▪ Town operation concerns- schools, roads/traffic, utilities. Optional reading “Governor Parris N. Glendening on smart growth” ***See Appendix E*** Town economic concerns- business ***See Appendix A for further details***
STEP THREE: Possibly collect ground validation data to access the accuracy of the change detection. ▪ Collect ground truthing data through fieldwork or from website (photos). ***SeeAppendix I. MUC-A-Thon and Δ NDVI-A-Thon Planning Guide***	**STEP THREE:** Determine the issues affected by growth ***English: Optional Extension Lessons: Conducting interviews and making presentations*** ▪ Students research their community member role using library notes and socio/demographic data ***See Appendix B*** ▪ Journal about character’s perspective ▪ Have the students create and then review the

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<td></td>
<td>questions to be used in the interview
Have the students conduct interviews with community members and begin to work on an essay and speech for a town meeting
See Appendix G List of characters/roles for the town meeting
History Lesson: Evaluation of Growth Trends
Use library notes and socio/demographic data to establish the effects of local growth trends.
See Appendix H Possible implementation timeline</td>
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<td>STEP FOUR: Prepare presentation

Five minute initial scientific presentation discussing findings and methodological improvements
Determine if government growth controls should be used
Visuals developed
Remotely sensed data and Landsat generated images are used to support various scientific community members points of view
Presentation
</td>
<td>STEP FOUR: Prepare presentation and conduct the town meeting
All subject areas- Optional Extension: Town meeting grading of oral presentation

Five minute initial presentation discussing main pros and cons
Determine if government growth controls should be used
Each person/group needs to present their argument/side and address each of these major issues plus any other pertinent issues. Ex. How would a low-income father of four who works at the local department store feel about each of these issues?
Practice presentation with all groups
Visuals developed
Remotely sensed data and Landsat generated images are used to support various community members points of view
Presentation

Simultaneous town meetings
Each viewpoint group gives a short presentation

Two minute rebuttal/question & answer period
Proposed solutions
Closing
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